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DOUGLAS-FIR TUSSOCK MOTH POPULATION MONITORING ON THE ELDORADO AND STANISLAUS NATIONAL FORESTS, CENTRAL SIERRA NEVADA, CALIFORNIA, 1996

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Background

The Douglas-fir tussock moth (DFTM), Orgyia pseudotsugata (Lepidoptera: Lymantriidae), is a native defoliator of true firs and Douglas-fir in western North American. There have been five major outbreaks of DFTM in California since 1935 (Table 1). Outbreaks tend to occur with little warning and last for three to four years. The primary host for DFTM in California is white fir and feeding by high densities of larvae can result in tree mortality, top-kill and growth loss with consequent diverse effects on forest ecosystems and resource management objectives.

Historically, DFTM outbreaks have been detected after some damage has already occurred, limiting effective management decision-making. In an effort to identify areas where DFTM populations are starting to increase toward outbreak levels, an "early warning" monitoring system has been implemented throughout the west, including northern California and the central Sierra Nevada. This system uses traps baited with synthetic DFTM female pheromone (sex attractant) to catch male moths (Daterman et al., 1976; 1979). The number of male moths captured can be an indication of the number of larvae that will be present the following spring and help identify areas where populations are increasing toward outbreak levels. The intent of providing an "early warning" of an outbreak is to give resource managers time to conduct decision support activities and allow for more timely decision-making.

In the fall of 1995, pheromone trap catches indicated that DFTM populations were increasing in several areas in the central Sierra Nevada. Subsequently, egg mass and larval surveys were conducted in May-July, 1996. The purpose of this report is to summarize the results of the monitoring surveys and discuss management implications.

DFTM Biology

The Douglas-fir tussock moth has a one year life cycle. Adult males fly from late July to early November depending on weather and location. Adult females have only rudimentary wings and do not fly. Females emit a sex attractant (pheromone) that attracts males during their flight period. After mating, the females lay eggs in masses on the foliage, the underside of twigs and branches, on the surface of the bark and in bark crevices. The number of eggs per mass is variable, generally ranging from 100 to 300. The eggs overwinter and hatch the following May/June in general synchrony with host tree shoot elongation. The larvae develop through five or six stages. The early stage larvae feed on the underside of the current years needles causing them to shrivel and turn brown. Older larvae will feed on both the current year and older foliage often consuming the entire needle. Pupation occurs from late July into August in the same locations as described for the egg masses.

Monitoring Results

1) Pheromone Early Warning Monitoring. An average trap catch of 25 moths per trap or more indicates that populations may be increasing toward outbreak levels (Daterman, et al. 1979). Results of the pheromone trap catches from locations in the central Sierra Nevada from 1990 to 1995 are given in Table 2. Of the 73 plots, 22 (30%) averaged 25 or more moths per trap, 9 (12%) averaged 20<25 moths per trap and 11 (15%) averaged 15<20 moths per trap. Most of the higher trap catches occurred on the Placerville District (Eldorado NF) and the three Districts on the Stanislaus NF. The two plots monitored by the California Department of Forestry and Fire Protection with high 1995 mean trap catches were located in Calaveras County and the Mariposa District (Sierra NF) had one plot with a high (31.8) moths per trap. With the exception of the Mammoth District (Inyo NF) on the east side of the Sierra Nevada and locations on the Mariposa District, there was an overall, generally consistent, increasing trend in trap catches from 1993 to 1995.

2) Egg Mass Monitoring. Egg masses were monitored with a technique utilizing artificial pupation shelters (Dahlsten et al., 1992). The artificial shelters are 10 by 9 by 4 cm wooden blocks with four 2.5 cm holes drilled in them. The shelters are attached to the bole of host white fir and larvae will sometimes use the holes as a pupation site. Egg masses from female pupae in the shelters have been significantly correlated with the following year's larval counts (Dahlsten et al. 1992).

Results of the 1994 and 1995 egg mass survey are given in Table 3. Although the number of egg masses is low, there was an increase from 1994 to 1995 (no egg masses were found in any of the artificial shelters in 1993). Plots on the Stanislaus NF had a higher number of egg masses per shelter than plots on the Eldorado. No egg masses and very few cocoons were observed on the foliage, branches or boles of white fir in the monitoring plots.

3) Larval Monitoring. Larval monitoring was conducted late June and early July, 1996, using a lower crown beating technique (Mason, 1977; 1979). This technique involves knocking early stage DFTM larvae from the lower crown branches of host white fir onto a drop cloth, determining the proportion of trees with larvae present, and converting the proportion of trees infested to

an estimated midcrown density expressed as the number of DFTM larvae per 0.64 sq.m (1000 sq. in) of foliage. Tussock moth defoliation usually becomes conspicuous (outbreak threshold level) at about 20 early stage larvae/0.64 sq.m. Densities of about 3 larvae/0.64 sq.m and greater have the potential to increase to outbreak levels the following year and are considered sub-outbreak; densities of less that 1 larvae/0.64 sq. m are at least two years away from reaching outbreak levels and are considered low-level (Mason, 1978).

Results of larval sampling in 1996 using the lower crown beating method are given in Table 4. Estimated midcrown densities on the Eldorado NF ranged from 0.58 to 1.47 larvae/0.64 sq.m and are classified as low-level. Stanislaus NF larval density estimates ranged from 6.4 to 12.5 larvae/0.64 sq. m and are classified as sub-outbreak.

Discussion

Historically, DFTM outbreaks in western North America have appeared to be synchronus, particularly in Washington. Oregon, northern Idaho and British Columbia (Shepherd et.al., 1988). Populations tend to increase to outbreak levels and collapse in a variable cycle that averages about 9 years between peaks. Since the 1950's in California, there has been one DFTM outbreak each decade and it has now been 9 years since the 1987-1989 outbreak in north central California. The monitoring results discussed above generally indicate that DFTM populations are increasing and have the potential to reach outbreak levels in the spring/summer of 1997.

Population monitoring is only conducted over a small proportion of the total area of potentially susceptible host type. Population increases similar to that being experienced currently have been detected in the past (e.g., 1984-1986), but the populations declined before reaching outbreak levels in the areas being monitored. Prior to the 1987-1989 outbreak, population increases were detected in several of the monitoring areas but the outbreak occurred in areas that were not being monitored. Population monitoring may give an indication that an outbreak is likely to happen within one to three years, but it is not always possible to predict with reliability exactly where within the host type the outbreak will occur. Thus (1), outbreaks may develop in areas that are not being monitored and (2), increasing populations do not always continue to increase to outbreak levels but decline, presumably due to interactions among naturally occurring biotic and abiotic factors.

From a management perspective, it is appropriate to monitor for evidence of DFTM feeding/defoliation on white fir throughout susceptible host type in the summer and fall of 1996. Susceptible host type includes mixed conifer stands with at least 35% white fir located on ridge tops and upper slopes (Williams, 1979). Feeding injury/damage is characterized by the browning ("burning") and shriveling of the current years needles and loss of older needles which may be most evident in the upper crown. In addition, silk strands or tents (produced by the larvae) primarily in the upper crown may be evident and from late-July through August, relatively large (25 to 30mm) hairy, colorful, larvae may be present on the foliage and/or crawling along the tree bole. Monitoring for evidence of feeding should be done on an informal, day-to-day basis, by field-going personnel as well as during aerial reconnaissance and aerial mortality survey flights.

Forest Pest Management (FPM) will continue monitoring cocoons/egg masses and adult males (pheromone traps) in established monitoring plots/sites. Forest/Districts might consider establishing additional pheromone plots in areas of susceptible host type not covered by the standard trapping system.

Depending on the results of this monitoring (i.e., if defoliation is observed and populations continue to increase), FPM and the Forests/Districts involved should discuss and evaluate potential effects of a DFTM outbreak and and the need for possible management actions.

Literature Cited

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Table 1. The Location, Duration and Size of Major Douglas-fir Tussock Moth Outbreaks in California, 1935-1989.

Years	Location/ County	Area of Defoliation
1935-1937	Mono	15,000 acres 6,070 hectares
1954-1956	Calaveras; Tuolumne	11,000 acres 4,450 hectares
1963-1965	Modoc; Plumas; Lassen; El Dorado	78,000 acres 31,570 hectares
1970-1972	Amador; Calaveras; El Dorado; Fresno; Madera; Mariposa; Shasta; Tulare; Tuolumne	100,000+ acres 40,470+ hectares
1987-1989	Lassen; Plumas; Sierra; Tehama	105,000 acres 42,500 hectares

Table 2. Mean Douglas-fir Tussock Moth Pheromone Trap Catches for Central Sierra Nevada Locations, 1990-1995.

Location/ Plot \1	Mean Number of Douglas-fir Tussock Moth Adult Males/Trap by Year 1990	1991	1992	1993	1994	1995
Eldorado NF						
Georgetown RD						
Nevada Point	0.0	0.0	0.2	0.0	0.0	0.6
Hales 1	0.2	0.0	0.2	0.2	0.2	3.8
Hales 2	0.6	0.0	0.6	0.4	0.8	11.2
Jerrys Pool 1	0.4	- -	1.0	0.0	0.0	11.2
Jerrys Pool 2	0.4	- -	0.4	0.0	1.2	13.6
Placerville RD						
Pebble Canyon	0.6	0.2	2.0	1.2	4.6	16.2
Stump Springs	0.8	0.4	2.2	0.4	2.2	18.8
49er Tree	0.0	1.6	1.2	0.2	2.2	23.2
Lower Baltic	0.4	0.2	2.4	0.2	5.0	18.6
Plummer	0.4	0.0	1.0	2.0	6.2	23.4
FPM IM 11-20	- -	- -	1.4	5.4	16.4	18.4
FPM IM 21-30	0.2	1.0	3.6	9.4	14.0	35.6
FPM IM 41-50	0.2	0.0	0.4	2.2	8.6	26.0
FPM IM 51-60	0.8	0.0	0.2	1.8	6.0	17.2
FPM IM 71-80	- -	- -	0.0	0.4	2.4	5.2
FPM BR 161-170	0.0	0.2	0.3	3.6	10.0	33.0
FPM BR 171-180	0.0	0.0	0.0	1.0	7.6	29.2
FPM BR 221-230	- -	- -	0.0	3.2	9.6	15.8
FPM BR 181-190	- -	- -	0.4	0.4	4.6	30.0
FPM BR 191-200	- -	- -	0.0	1.2	5.0	11.0
FPM BR 201-210	0.0	0.2	0.4	1.8	5.0	14.0
FPM BR 231-240	- -	- -	0.0	0.8	4.2	14.6
FPM BR 211-220	0.0	0.2	0.2	1.2	7.6	29.8
FPM PR 91-100	0.0	0.8	1.0	3.8	4.8	29.4
FPM PR 101-110	- -	- -	3.6	4.8	11.6	30.4
FPM PR 111-120	0.2	3.2	1.4	3.4	8.0	21.2
FPM PR 121-130	- -	- -	1.0	5.0	6.6	18.4
FPM PR 131-140	2.8	0.2	1.3	22.8	7.6	26.0
FPM PR 141-150	- -	- -	0.6	2.2	1.6	13.4
FPM PR 151-160	0.5	0.0	1.2	9.8	7.8	17.6

Table 2. (continued)

Amador RD

Lumberyard 1	0.0	0.0	0.8	0.4	0.0	1.0
Lumberyard 2	0.2	0.0	0.4	0.0	0.4	3.2
Mud Springs	0.2	0.2	0.0	0.2	2.8	5.8
Mud-Hams	4.0	0.4	8.4	0.2	11.8	22.0

Inyo NF

Mammoth RD

Outbreak	0.2	1.0	0.0	0.4	8.2	1.4
Scenic	0.2	0.0	0.0	0.2	7.0	0.0
Plantation	0.0	0.0	0.0	0.0	1.2	1.0
Unit 5	0.0	0.2	0.0	0.0	2.0	0.6

Stanislaus NF

Calaveras RD

Mattley 1	0.0	0.0	0.0	0.0	0.4	2.0
Mattley 2	0.0	0.0	0.2	0.0	0.6	8.6
Bailey	0.2	0.0	6.2	2.0	7.4	16.8
Summit Level 1	0.2	0.0	5.2	8.0	5.6	32.4
Summit Level 2	0.0	0.0	0.4	3.4	2.8	21.8
Skull Peak	0.6	5.0	0.0	0.6	1 0	28.8
Thunder Hill 1	0.0	0.2	0.2	1.4	3.4	5.6
Thunder Hill 2	0.0	0.0	0.3	2.2	1.2	16.6
Thunder Hill 3	0.0	0.0	0.8	0.8	3.6	26.0
Thunder Hill 4	1.2	0.2	3.2	0.2	9.6	23.6
Chinaman	0.6	1.4	5.8	11.8	17.2	37.2

Mi-wok RD

Hull Meadow	2.0	- -	3.6	2.4	2.8	36.2
Two Mile	0.6	- -	0.2	0.0	0.2	40.4
Reynolds	0.2	- -	0.4	0.0	0.2	0.6
Little Reynolds	0.0	- -	1.6	0.4	0.4	24.4
Dodge	0.2	- -	2.2	0.4	0.4	31.4
Lily	0.6	- -	0.0	0.2	0.0	17.4
Dodge Ridge 1	0.0	- -	0.4	1.6	2.2	28.8
Dodge Ridge 2	0.0	- -	0.4	0.0	0.2	23.0

Summit RD

Strawberry 1	0.0	- -	0.4	0.0	0.2	23.0
Strwaberry 2	0.4	0.0	5.6	10.8	23.4	29.6
Strawberry 3	0.4	0.0	2.8	5.4	18.4	35.5

Table 2. (continued)

Sierra NF

Mariposa RD

Water Line	0.0	0.0	0.0	0.2	0.2	0.0
Long Meadow	0.0	0.0	0.0	0.0	0.0	0.0
White Chief	0.0	0.0	0.0	0.0	0.0	0.0
Beasore	0.0	0.0	0.0	0.0	0.0	0.0
Grays	0.6	0.0	0.0	1.0	1.2	10.6
Poison	0.0	0.0	0.0	0.2	0.0	1.0
Chipmunk	0.0	0.0	0.0	0.0	0.0	0.0
Speckerman	0.0	0.0	0.0	0.0	0.0	1.4
Kramer	0.3	0.0	0.0	0.0	0.8	0.0
Sivels	1.6	3.6	0.0	0.8	1.2	31.8

CDF (Calaveras County)

Bailey Ridge	0.3	0.2	2.8	2.0	15.6	35.6
Hermit Springs	0.3	0.0	0.4	0.0	1.4	1.4
Dorrington	0.0	0.2	1.0	1.2	4.6	31.0

\1 N= 5 traps per plot.

Table 3. Mean Number of Douglas-fir Tussock Moth Egg Masses Collected in Artificial Shelters in Central Sierra Nevada Locations, 1994-1995.

Location/ Plot		Number of Artificial Shelters	Total Number of Egg Masses and Mean Number of Egg Masses/Shelter, 1994 and 1995			
			1994		1995	
			No.	Mean	No.	Mean
Eldorado NF						
Placerville RD						
FPM IM	1-10	13	2	0.15	2	0.15
FPM IM	11-20	15	0	0.00	0	0.00
FPM IM	21-30	20	0	0.00	0	0.00
FPM IM	31-40	16	0	0.00	0	0.00
FPM IM	41-50	13	0	0.00	2	0.15
FPM IM	51-60	12	0	0.00	0	0.00
FPM IM	61-70	18	0	0.00	1	0.06
FPM IM	71-80	17	0	0.00	1	0.06
Total	1-80	124	2	0.02	6	0.05
FPM BR	161-170	19	0	0.00	0	0.00
FPM BR	171-180	17	3	0.18	2	0.12
Total	161-180	36	3	0.08	2	0.06
FPM PR	81-90	15	1	0.07	1	0.07
FPM PR	91-100	8	0	0.00	2	0.25
FPM PR	101-110	12	0	0.00	2	0.17
FPM PR	111-120	17	3	0.18	1	0.06
FPM PR	121-130	9	0	0.00	0	0.00
FPM PR	131-140	21	2	0.10	4	0.19
FPM PR	141-150	10	0	0.00	0	0.00
FPM PR	151-160	23	0	0.00	1	0.04
Total	81-160	115	6	0.05	11	0.10
Amador RD						
Lumberyard 1		20	1	0.05	2	0.10
Mud-Hams		12	1	0.08	1	0.08
Total		32	2	0.06	3	0.09

Table 3. (continued)

Stanislaus NF					
Calaveras Rd					
Summit Level 1	8	0	0.00	1	0.13
Summit Level 2	6	2	0.33	3	0.50
Total	14	2	0.14	4	0.29
Mi-wok RD					
Hull Meadow	10	0	0.00	2	0.20
Two Mile	10	2	0.20	1	0.10
Dodge	10	0	0.00	2	0.20
Dodge Ridge 1	10	7	0.70	6	0.60
Total	40	9	0.23	11	0.28
TOTAL Eldorado NF	307	13	0.04	22	0.07
TOTAL Stanislaus NF	54	11	0.20	15	0.28
GRAND TOTAL	361	24	0.07	37	0.10

Table 4. Estimated Midcrown Densities of Early Stage Douglas-fir Tussock Moth Larvae for Central Sierra Nevada Locations, 1996.

Location	Number Larvae	Proportion Samples Infested (\1)	Estimated Midcrown Density (\2)
Eldorado NF \3			
Placerville RD			
FPM IM 1-10	12	0.32	0.77
FPM IM 21-30	19	0.44	1.16
FPM IM 41-50	14	0.44	1.16
FPM IM 51-60	13	0.36	0.89
Total	58	0.40	1.02
FPM PR 91-100	8	0.24	0.58
FPM PR 111-120	12	0.40	1.02
FPM PR 131-140	24	0.24	0.58
FPM PR 151-160	25	0.40	1.02
Total	69	0.31	0.74
FPM BR 161-170	18	0.40	1.02
FPM BR 171-180	7	0.24	0.58
Total	25	0.32	0.77
Amador RD			
Lumberyard 1	24	0.52	1.47
Mud-Hams	24	0.52	1.47
Total	48	0.52	1.47
Stanislaus NF \4			
Calaveras RD			
Summit Level 1	45	0.80	6.4
Summit Level 2	32	0.84	7.4

Table 4. (continued)

Mi-wok RD			
Hull Meadow	77	0.96	12.5
Two Mile	57	0.92	10.3
Dodge	82	0.92	10.3
Dodge Ridge	84	0.88	8.6
TOTAL Eldorado NF	200	0.38	0.96
TOTAL Stanislaus NF	377	0.90	9.20

\1 N= 25 trees per plot.

\2 Number of larvae per 0.64 sq. m (1000 sq. in) of foliage.

\3 Larval sampling conducted July 1-2, 1996.

\4 Larval sampling conducted June 24, 1996.